Token-Based Platforms and the ‘Green Dilemma’: Awareness Spillover and Environmental Impact Disclosures

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Abstract

While the environmental impact has become an important IT governance agenda in recent years, it is unclear whether its disclosure is valued by token holders of platforms based on blockchain IT infrastructure and how these platforms react to changing public awareness of their environmental impacts. We consider Elon Musk’s 2021 announcement that Tesla would suspend accepting Bitcoin as payment because of Bitcoin mining’s environmental impact as a shock that dramatically increases awareness of Bitcoin mining’s environmental impacts. We find that, subsequent to the shock, infrastructure platforms which have larger environmental impacts than application platforms, are more likely to disclose environmental impact information than application platforms and that their token market values grow at a slower rate, consistent with the increased awareness spills over to other token-based platforms. Furthermore, whereas pre-shock environmental impact disclosure by infrastructure platforms reduces token market value growth rates, post-shock disclosure has the opposite effect, consistent with green-costing and green-enhancing, respectively.

Keywords: token-based platform, IT infrastructure, awareness, environmental sustainability

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1 Introduction

The governance of information technology (IT) infrastructure is an important topic, as IT infrastructures serve as the foundation for other IT applications (Xue et al., 2011). One aspect of such governance is assessing the impact of IT infrastructure on environmental sustainability. Despite its importance, this topic is rarely explored in the information systems (IS) literature (Melville, 2010). The current research aims to respond to the calls for new research on the managerial, organizational, and economic impact of blockchain IT infrastructure (Constantinides et al., 2018) by investigating the changes in environmental impact disclosure and the growth of token-based platforms following a shock that increases public's awareness of the environmental impact of Bitcoin, which thereby advances understanding of these platforms' responses to the token holders' shifting awareness of environmental sustainability issues.

Token-based platforms are digital platforms that secure asset ownership and facilitate transactions via digital tokens which are the fundamental units of asset ownership, value storage, and exchange (Cong and He, 2019), underpinning decentralized financial activities. By creating new tokens or leveraging existing tokens, these platforms integrate payments, asset trading, and other applications in an open blockchain infrastructure with little central control or regulation. Despite the significant role of token-based platforms in the digital economy and their surging economic impact, the existing literature does not clearly distinguish between types of token-based platforms that exert disparate degrees of environmental hazard. The current study delves into the heterogeneity of token-based platforms in the context of environmental impact.

Leveraging Elon Musk's May 2021 announcement regarding Tesla[1]'s suspension of accepting Bitcoin as payment because of Bitcoin mining's negative environmental impact ('the announcement') as an event study (online Appendix figure 1), we find that only

[1]Tesla (https://www.tesla.com) is one of the world's most valuable companies and, as of 2023, is the world's most valuable automaker. In 2022, the company led the battery electric vehicle market, with 18% share (source: Wikipedia).

seven platforms, each with a token market value at least US$300 million, had published their environmental impacts on web pages before the announcement (online Appendix figure 2 and table 1). However, the number increased by nearly 500% (to 34) after the announcement, between May 2021 and March 2023. Such a dramatic change in disclosure level before and after the announcement offers a rare opportunity to study the effects of public awareness on the environmental impact disclosure of decentralized IT infrastructure as exemplified by token-based infrastructure platforms.

There seems to be no looming external regulatory pressure or internal motivation for platforms to deviate from existing disclosure practices unless they experience and respond to a major exogenous impact. First, there are no regulations that these platforms need to disclose environmental information. Unlike publicly traded companies, for which environmental impact disclosure have been proposed[2], token-based platforms are not subject to the same regulations. Second, platforms can disclose environmental information at a low cost because they primarily affect the environment through the energy consumption used in maintaining the digital platform. This usage can be derived from predetermined consensus algorithms and the computing difficulty in historical block verification (Ziolkowski et al., 2020). Our research question is as follows. *How has the increased public awareness of Bitcoin mining since the announcement influenced the environmental impact disclosure of token-based platforms and their token market value growth rates (TMVGRs)?* The token market value of token-based platforms is analogous to the capitalization in the stock market (Kogan et al., 2017), which equals the token price times circulating supply.

The literature presents competing views on the effects of environmental impact disclosure on platforms' TMVGRs, which we refer to as the '**Green Dilemma**'. On the one hand, token-based platforms may be incentivized to voluntarily disclose information in an attempt to reduce information asymmetry (Howell et al., 2020) and improve repu-

[2] For instance, the European Union's Non-Financial Reporting Directive requires certain companies to make environmental impact disclosures and expands the scope to 50,000 listed companies in 2023.

tations (Avramov et al., 2022), which we refer to as the 'green-enhancing effect'. On the other hand, such disclosures may be regarded as a waste of resources derived from agency problems between shareholders and managers (Krüger, 2015), and as diverting attention away from a platform's core business (Hirshleifer and Teoh, 2003). We refer to this negative effect as the 'green-costing effect'. In the current research, we examine whether the increased public awareness of Bitcoin mining's negative environmental impacts influences these two competing effects for token holders.

Our model-free evidence based on Google Trends shows the announcement brought significant public attention to the energy-consuming mining operations of Bitcoin, as shown in the sudden search volume increase of 'Bitcoin Environment' (Figure 1). Although the announcement only mentioned Bitcoin, we find that the public may become aware of energy consumption of other token-based platforms and consider their environmental implications, suggesting an **'awareness spillover effect'**.

We classify token-based platforms into two types based on their operations (Figure 2): (1) **infrastructure platforms (IPs)**, such as Ethereum[3], which continually expands the blockchain length through the mining of new blocks; and (2) **application platforms (APs)**, such as Sandbox[4], which do not have their own blockchain but create their contracts and issue tokens on IPs.

We expect that the spillover of public awareness to be more intensive toward IPs than APs, as only IPs directly engage in energy-intensive mining. We first study how the increased public awareness of Bitcoin mining's environmental impacts influenced the TMVGRs of IPs and APs. Our results show that after the awareness increases, IPs' TMVGRs decrease more than those of APs. We then investigate whether the increased public awareness leads to more environmental impact disclosures. We focus on environmental web pages as they serve as vital information sources for token holders to understand

[3]Ethereum (https://ethereum.org) is a decentralized blockchain with smart contract functionality. Among cryptocurrencies, ether is second only to bitcoin in market capitalization (source: Wikipedia).

[4]Sandbox (https://www.sandbox.game/), a Metaverse token-based platform built on Ethereum and Polygon, issues a fungible token called Sand for circulation.

the operation and performance of a platform (Lynch and Taylor, 2021). As expected, we find a significant increase in environmental web pages launched by IPs, but not by APs, after the shock.

Both pieces of evidence are consistent with that a spillover of awareness on energy consumption of Bitcoin influences the IPs and their token holders. We also study whether environmental impact disclosures by IPs can mitigate the awareness spillover and find that IPs' TMVGRs significantly increase after their disclosures. To mitigate the concern that publishing any web page could increase a platform's TMVGR, we conduct a falsification test using social pages and find null results, consistent with the increase in TMVGR driven by environmental impact disclosure. Finally, we show that before the shock, IPs' TMVGRs decrease after their web page environmental impact disclosure. Taken together with our earlier evidence on the positive effect of environmental disclosure on TMVGR after the shock, we conclude that the awareness spillover moderates the green-costing effect of these disclosures.

Our work contributes to the literature in several aspects. First, we contribute to the discussion of IT infrastructure governance by showing that IT environmental sustainability awareness can significantly influence the disclosure practices of infrastructure platforms. In response to the call for blockchain IT infrastructure governance (Constantinides et al., 2018), we differentiate IT infrastructure and IT applications from token-based platforms by demonstrating their differential reaction to the spillover of awareness of mining's environmental impact.

Second, our study contributes to the environmental sustainability in IS by assessing outcomes of environmental impacts information disclosure (Melville, 2010). Most studies focus on green IS conceptualization (Malhotra et al., 2013; Seidel et al., 2013), and effects measurement (Leidner et al., 2022; Saldanha et al., 2022), but analyses of the green effect trade-off are scant. The most closely related empirical study (Hu et al., 2016) shows that contextual factors, such as the general public's awareness, correlate with adopting these practices. Our study, however, differs by investigating awareness's moderating effect on the trade-off between green-costing and green-enhancing effects from a longitudinal perspective.

Third, the token literature explores theoretical models of tokens (Chod and Lyandres, 2021; Cong and He, 2019; Sockin and Xiong, 2023), initial coin offerings (ICOs) (Howell et al., 2020; Malinova and Park, 2023), mining scalability (Cong et al., 2023), and conflict resolution (Bakos and Halaburda, 2022; Gudmundsson et al., 2023). The most closely related study (Bourveau et al., 2022) explores the impact of voluntary disclosure on ICO success. However, our research differs by focusing on environmental impact disclosure data, and these disclosures often happen in the post-ICO period. Besides, we improve the empirical methodology of token studies by emphasizing the need to control for omitted operational cost variables to make IPs and APs comparable.

Lastly, we contribute to the corporate social responsibility (CSR) literature on legitimacy theory (Cho and Patten, 2007). Few empirical studies provide consistent support for its argument that public pressure can influence the extent of CSR disclosure, because companies may anticipate that such social pressure will lead to later regulatory requirements (Fiechter et al., 2022; Michelon et al., 2020). Given the setting that token-based platforms have no regulatory need to disclose environmental impact information, we show that social pressure itself can influence the extent of their environmental impact disclosure.

2 Institutional Background

Blockchain and tokens are integral components of digital platforms (Hendershott et al., 2021). **Blockchain** can securely and consistently record and verify data across a decentralized network (Cho et al., 2021; Liang et al., 2021). Blockchain functions as a database (Constantinides et al., 2018), which has great utility when recording data of token ownership changes (Chen et al., 2023). Token-based platforms in this study are based on the public blockchain that enables anyone to view and submit transactions (Ziolkowski et al., 2020). **Token** functions as a digital identifier that represents ownership of both virtual and physical assets (Ziolkowski et al., 2020). Tokens can be registered on any database (Bauer et al., 2022), including non-blockchain databases, although registering in blockchain can facilitate the transfer of tokens across a decentralized network.

Token-based platform includes both IPs and APs. IPs support the basic data recording services via blockchain that requires mining to validate transactions and generate new blocks (Basu et al., 2023). APs, in contrast, provide services by leveraging decentralized data services provided by IPs. APs are less reliant on mining than are IPs, but they pay operation fees to IPs for their services (Ziolkowski et al., 2020). For example, Metaverse token-based platforms can be classified as APs. They rely on IPs for token issuance, transaction, and redemption.

3 Hypothesis Development

Figure 3 shows our research model. We examine whether the public awareness of Bitcoin mining's environmental impacts influences the environmental impact disclosure of token-based platforms and their TMVGRs. The token market value changes through two channels: token supply fluctuations (including new token issuance and token redemption) and buy/sell transactions on the secondary market where token price depends on the transaction demand (Cong et al., 2021). We measure platform performance via TMVGR rather than price return because the token supply is highly dynamic and price cannot reflect token issuance and token redemption activities timely (Sockin and Xiong, 2023). Token issuance and redemption reflect the adoption and disadoption of token-based platforms, respectively. Token transactions reflect the utility of the token, which determines its price in secondary markets (Cong et al., 2021). Overall, TMVGR can measure the performance change in token issuance, redemption, and transaction demand.

3.1 Awareness and Platform Performance

The awareness of Bitcoin mining's impact is likely to spill over to the awareness of mining's energy consumption of other IPs. We designate IPs as the treatment group and APs as the control group. Because only IPs are directly involved in mining, we hypothesize as follows:

Hypothesis 1 *The awareness of Bitcoin mining's environmental impacts decreases the TMVGRs of IPs, but not APs.*

3.2 Awareness and Platform Disclosure

Platforms are expected to disclose relevant information to alleviate concerns about mining and meet the expectations of token holders (Cho and Patten, 2007). Given that only IPs are directly involved in mining, we propose the following hypothesis:

Hypothesis 2 *The awareness of Bitcoin mining's environmental impacts leads IPs to disclose more environmental impact information than APs.*

3.3 Platform Disclosure and Platform Performance

Environmental impact disclosures can exert two opposing effects on platform performance: (1) a green-enhancing effect due to potential reputation enhancement (Avramov et al., 2022), or 2) a green-costing effect due to potentially unprofitable actions (Krüger, 2015). As suggested by Hypothesis 1, IPs may experience a decrease in TMVGRs due to their perceived negative environmental impacts, which indicates that the token holders have a net green-enhancing viewpoint. In contrast, before the awareness, environmental impact disclosure may be viewed as unprofitable (Krüger, 2015), because only a few platforms have disclosed environmental information or because token holders are indifferent to potential negative environmental impacts (Aswani et al., 2024; Moss et al., 2023). Thus, to test the moderating role of the awareness, we propose the following hypothesis:

Hypothesis 3 *The awareness moderates the green effect of IPs' environmental impact disclosures such that the green effect is negative (positive) before (after) the awareness.*

4 Data and Statistical Summary

4.1 Financial Panel Data

We collect financial data of the study platforms from Coinmarketcap[5], focusing on token-based platforms with a token market value of at least US$100 million[6]. To examine the impact of the shock on 12 May 2021, we focus on 12 April to 12 June 2021. Our baseline data consists of 409 distinct platforms (133 IPs and 276 APs), totaling 23,570 platform-day observations. We exclude Bitcoin because of its direct involvement in Elon Musk's announcement, as token holders' reactions could stem from Bitcoin's decreased payment utility rather than its environmental implications. We also exclude stablecoin platforms to avoid endogeneity concerns, because the TMVGRs of both IPs and APs influence the TMVGRs of stablecoin platforms. Most stablecoin platforms serve as a bridge between fiat currencies and digital tokens, including IP and AP tokens.

4.2 Web Page Data

Platform web pages inform token holders of platforms' mission, strategies, and operation (Bourveau et al., 2022), which often share similar designs, allowing for catego-

[5]CoinMarketCap (https://coinmarketcap.com/) reports secondary market data for thousands of tokens and is generally perceived to be the highest-quality source for such data.

[6]The token market value of one platform can be converted to USD according to its token price and supply.

rization. We manually collect 2,600 web pages from the top 200 token-based platforms (stablecoin platforms are excluded) by market capitalization as of April 1, 2023, and categorize them into eight distinct types (see category definitions in the online Appendix A). We utilize the Wayback Machine[7] and extract the first archived date for each page, as the earliest page reflects the primary change in environmental impact disclosure and has the largest impact on token holders, as compared with later complementary disclosures. Our dataset comprises 2,382 unique pages, excluding pages that are not archived by the Wayback Machine. Considering the Wayback Machine's indexing delay, we verify launch dates with corresponding environmental news reports to ensure the precision of our data.

To study the post-shock green effects, we create a panel that incorporates 85 IPs, of which 41 have environmental web pages. We remove Bitcoin and five IPs with environmental web pages published before 12 May 2021. The final after-shock panel data consist of 40,768 observations spanning 12 May to 1 March 2023. To study the pre-shock green effect, we find five IPs – EOS, XRP, ALGO, HOT, and NEAR – with published environmental web pages before 12 May 2021. Two platforms (CSPR and MOB) are excluded as their financial data start 6 months after their environmental page publication. The final all-period panel data comprise 66,197 observations.

4.3 Statistical Summary

Table 1 describes two primary datasets. The dependent variable TMVGR has an average value close to 0, but its minimum and maximum values are large, indicating significant reactions from token holders during this period. We use the log difference to calculate TMVGRs, achieving a balanced magnitude between maximum negative and maximum positive TMVGRs. The control variables include prior market value, three time-trend control variables, and overall market change. The three-month period can capture long-

[7]Wayback Machine (http://archive.org/web/) is an online archive of past instances of websites.

term trends because of the 24/7 trading on token exchanges. We exclude data points if the value of any control variable is missing.

In the baseline data, the explanatory variable '*PostShock*' has an average value of 0.54, implying a balance of observations between the pre-shock period and post-shock periods. In the IP panel data, '*Post*' has a mean of 0.06, meaning that only a small proportion of the dataset's observations come from the post-disclosure period because we include all data from the pre-disclosure period and 3 months of data from the post-disclosure period. For heterogeneous variables, we include two indicators of the degree of regulation (defined in Appendix A). We include all-period IP disclosure data statistical summary in the online Appendix table 5.

5 Empirical Strategies and Results

5.1 Difference-in-Difference

We use a difference-in-difference (DID) approach (model 1) with APs as the control group and IPs as the treatment group. Hypothesis 1 suggests that after the awareness increases, the TMVGRs of treated units (IPs) decrease more than those of control units (APs). Although both IPs and APs are token-based platforms, APs necessitate the payment of fees to function on IPs, creating a dependence of APs on IPs. Thus, to make IPs and APs comparable, we incorporate the price and total supply of IP tokens as control variables because they are directly correlated with the operation costs of APs. To infer causality, we must further check the parallel trend assumption. Model 2 explores the dynamics of the treatment effects within the preceding and subsequent 5 days. The model uses indicators for the time distance to and from the shock.

$$Y_{it} = \alpha_i + \delta_t + \beta \times PostShock_t \times IP_i + Control_{i,t-1} + \epsilon_{i,t} \tag{1}$$

$$Y_{it} = \alpha_i + \delta_t + \sum_{k=-5,k\neq-1}^{5} \beta_{k(t)} \times IP_i + Control_{i,t-1} + \epsilon_{i,t} \tag{2}$$

where Y_{it} represents the TMVGR for platform i in day t. $Control_{i,t-1}$ includes various time series control variables. To address concerns regarding unobserved endogenous platform characteristics and macro trends across distinct temporal periods, we incorporate both platform-level fixed effects α_i and year-by-month-by-day fixed effects δ_t. The platform fixed effects can capture unobserved platform characteristics, and the time fixed effects capture macro time trends each day. $Post_t$ and IP_i are absorbed by the fixed effects as they are unit-invariant or time-invariant. $\beta_{k(t)}$ and IP_i are absorbed by fixed effects as they are unit-invariant or time-invariant.

Table 2 indicates that after the shock, IPs' TMVGRs decrease more than those of APs. The entity-clustered standard error provides a more precise result. According to columns (1) and (4), after the shock, IPs' TMVGRs decrease more than those of APs by 0.53% on average. This effect becomes more salient after controlling other factors influencing IPs' TMVGRs, as shown by 1.47% in columns (2) and (5), and 1.44% in columns (3) and (6). We report the results of model 2 in the online Appendix table 3 and figure 3, which suggest no significant difference between the treatment group and control group during the pre-shock period and a significant negative coefficient in the post-shock period, indicating larger reductions in TMVGRs in the treatment group (IPs) than in the control group (APs). Thus, Hypothesis 1 is supported.

5.2 Chi-Square Test

We use the chi-square test to assess the statistical significance of the change in the number of environmental impact disclosures between the pre- and post-shock periods. Table 3 suggests a significant increase in the number of IPs, not APs, that published environmental web pages. Before the awareness increases, only seven IPs published environmental web pages over three years. After the awareness, the number of

IPs publishing environmental web pages dramatically increased by 500% within eighteen months. The Chi-square statistic is computed as: $\chi^2 = \frac{(7-16.65)^2}{16.65} + \frac{(78-68.35)^2}{68.35} + \frac{(34-24.35)^2}{24.35} + \frac{(51-60.65)^2}{60.65} = 8.36$. The critical value for a significance level of 0.01 is 6.63 (freedom = 1). As the calculated chi-square value, 8.36, is greater than the critical value, we reject the null hypothesis that there is no significant increase in the number of environmental web pages published by IPs after the awareness increases. For APs, however, because no environmental web pages were published before or after the awareness increases, no change in behavior is observed. The pre-shock period is much longer than the post-shock period. We expect that if we keep period lengths the same, the contrast will become even more salient. Thus, Hypothesis 2 is supported.

5.3 Staggered Adoption Difference-in-Difference

We use IP panel data to study the effect of environmental impact disclosure on IPs' TMVGRs (green effect). Because platforms publish environmental web pages at different time points, we employ a staggered adoption DID model, model 3, to test the green effects. Our two-way fixed-effects model compares the differences in IPs' TMVGRs between the control and treatment groups before and after environmental impact disclosure. The control group consists of platforms that have not yet published environmental web pages, whereas the treatment group consists of platforms that have published environmental web pages. To compare the heterogeneous periods, we use another staggered adoption DID regression model, model 4 with a heterogeneous time variable $Before_t$. Model 3 and 4 are presented as follows:

$$Y_{it} = \alpha_i + \delta_t + \beta \times Post_{it} + Control_{i,t-1} + \epsilon_{i,t} \tag{3}$$

$$Y_{it} = \alpha_i + \delta_t + \beta \times PreShock_t \times Post_{it} + \gamma_1 \times Post_{it} + Control_{i,t-1} + \epsilon_{i,t} \tag{4}$$

where Y_{it} represents TMVGRs of platform i in day t. $Post_{it}$ represents the web page launch dummy variable for platform i on day t. Similar to model 1, we incorporate both platform-level fixed effects α_i and year-by-month-by-day fixed effects δ_t. $PreShock_t$ is a dummy indicator showing whether the time is before the shock, which is absorbed by the fixed effects as it is unit-invariant.

Table 4 presents the estimation results for model 3 and 4. Columns (1), (2), and (3) show that after the web page environmental impact disclosure, IPs' TMVGRs increase by 0.29% on average. According to columns (4), (5), and (6), the awareness moderates the green effect. Column (4) shows that the increased public awareness increases the effect by 1.03%. During the pre-shock period, IPs' TMVGRs decrease by 0.73% on average (0.30%–1.03%) after web page environmental impact disclosures. In columns (5) and (6), the estimates have a similar significance level, suggesting that the awareness increases the effect by 0.99% and 0.98%, respectively. We find evidence for the green-costing effect during the pre-shock period, and the increased public awareness dramatically increases this green effect. Thus, hypothesis 3 is supported.

5.4 Falsification Check and Heterogeneous Effect Test

To mitigate concerns that any web page would increase a platform's TMVGR, we conduct a falsification check with social pages, as social pages are also ESG[8]-related pages and thus comparable to environmental pages. We find that social pages have null effects during the post-shock period.

Regulation lags behind the development of these platforms, resulting in financial woes that have recently appeared in media headlines[9]. We verify the absence of regulatory concerns within the token market by studying heterogeneous platform's legal status. We construct two variables to indicate the degree of regulation: *Registration* and

[8]Environmental, social, and governance.

[9]For instance, the crash of Luna is estimated that $60 billion got wiped out of the digital currency space (Forbes).

Address (defined in Appendix A). If regulatory intensity did play a role, platforms subject to stricter regulation would benefit from such disclosures more than other platforms because of their compliance requirements. We find that different degrees of regulation do not have significantly different green effects (online Appendix table 4), which aligns with the argument that in loosely regulated markets, investors tend to disregard regulatory risks (Avramov et al., 2022; Ilhan et al., 2021).

6 Conclusion

The governance of IT infrastructure, including blockchain infrastructure, has emerged as a topic of importance. One aspect of such governance is assessing its impact on environmental sustainability. Despite its importance, this topic is rarely explored in the IS literature. The current study finds the increased awareness of Bitcoin mining's negative impacts spills over to other token-based platforms and moderates the green effects, which advances our understanding of these platforms' responses to the public awareness of environmental issues. As blockchain represents an emergent form of IT data infrastructure, our findings show the heterogeneity of token-based platforms by dividing them into IPs and APs and their disparate degrees of environmental hazard. The layered structure between infrastructure platforms and application platforms reveals the complex interplay between IT governance and environmental responsibility.

Our research underscores the role of awareness in IT infrastructure governance practices for policymakers and platforms. As awareness could be shaped by non-regulatory means, policymakers should emphasize education campaigns to promote environmentally conscious practices and awareness of their long-term benefits, especially in such a global and unregulated Web 3.0 market. Besides, policymakers should ensure the reliability of disclosed environmental information by discouraging deceptive 'greenwashing' and promoting genuine sustainability efforts. Furthermore, platforms should consider the timing of their disclosure. Disclosing environmental information during periods of low awareness may backfile, even if eco-friendly practices are genuine. Lastly, we also provide implications to token holders, especially short-term token investors, who should consider awareness spillover in their investment strategies.

Our research has certain limitations. Firstly, we focus on platforms with a token market value of over US$100 million, which may not fully capture the full market, even though such platforms are the most influential with higher data quality. Secondly, awareness is a complex construct and difficult to measure accurately without surveys. We use a dummy variable to measure the relative change. Thirdly, we focus on the web page environmental impact disclosure. Although web pages serve as the primary information source for platforms, considering alternative channels that target specific subgroups of token holders could be more comprehensive. Fourthly, considering IPs' self-reported data are not verified, the current research does not investigate their heterogeneous energy consumption. Lastly, we estimate only the net effect rather than the individual green-costing and green-enhancing effects. Future studies should investigate the mechanism that produces the green-costing and green-enhancing effects observed in the current study.

Appendix A: Variable Definitions

Variable	Definition
$TMVGR_t$	Daily percentage change in the platform's market capitalization (size).
IP_i	Indicator variable that equals one for token-based platforms are IPs and zero for APs.
$PostShock_t$	Indicator variable that equals zero if the date is before May 12, 2021, and one otherwise.
$Post_{it}$	Indicator variable that equals to one if the date is after web page environmental disclosure, and zero otherwise. The variable varies across time and units.
$Environment_i$	Indicator variable that equals one if the web page disclosure is environmental information, and zero if the web page disclosure is social information.
$PreShock_t$	Indicator variable that equals one if the date is before May 12, 2021, and zero otherwise.
$Supply_{t-1}$	The circulating amount to tokens one day prior, calculated by the market cap divided by token price.
$LogSize_{t-1}$	The natural logarithm of market capitalization one day prior.
$WeekReturn_{t-1}$	Percentage change in the token price during the previous week one day prior.
$MonthReturn_{t-1}$	Percentage change in the token price during the previous month one day prior.
$ThreeMonthReturn_{t-1}$	Percentage change in the token price during the previous three months one day prior.
$Close_{t-1}$	Daily closing price of the token one day prior.
$AllMktCapChange_{t-1}$	Percentage change in the overall token market capitalization one day prior.
$Registration_i$	Indicator variable that equals to one if a token-based platform is officially recognized as a legal entity in a particular country, and zero otherwise.
$Address_i$	Indicator variable that equals to one if a token-based platform is officially registered with a full address for its organization, and zero otherwise.

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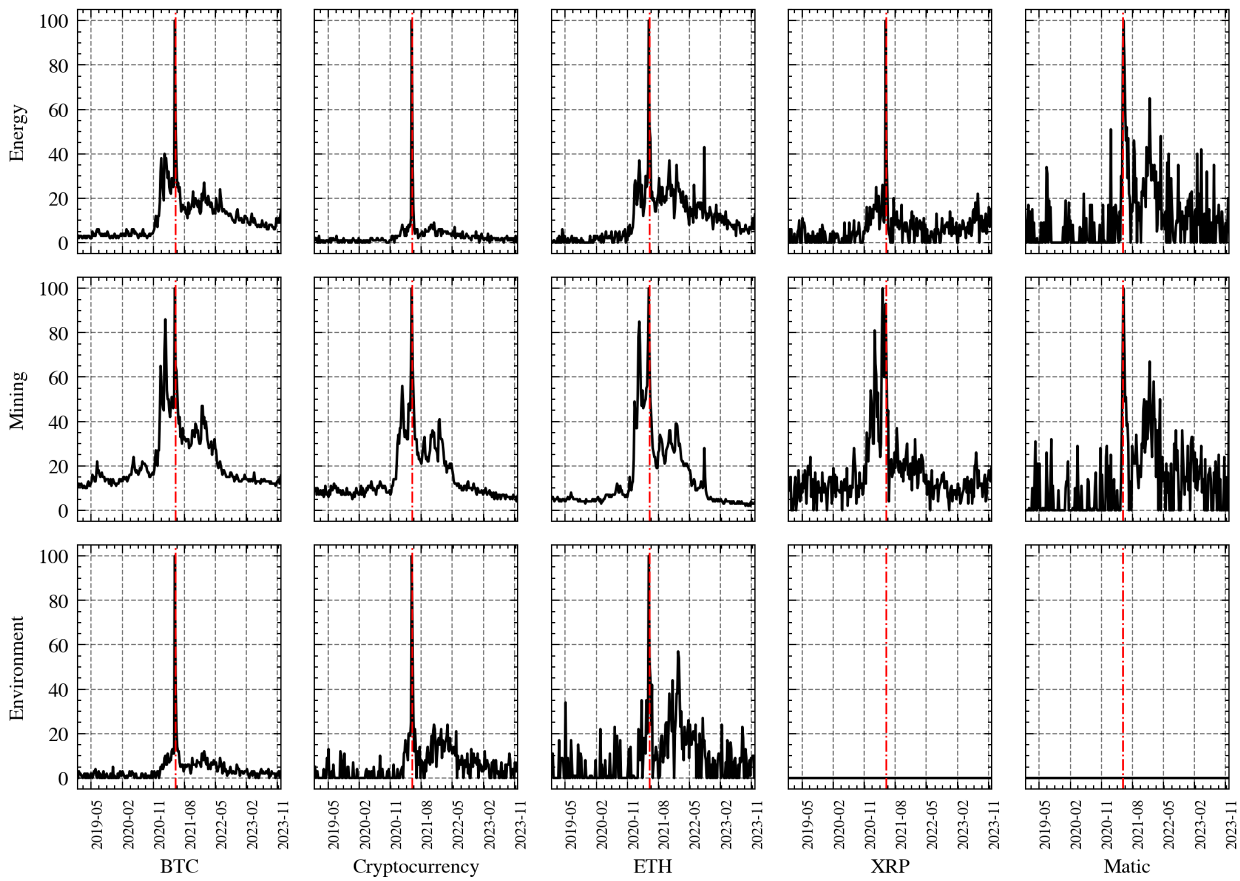

Figure 1: Weekly trends of worldwide search volume in cryptocurrency-related energy, mining, and environment from 2019 to 2023 on Google Trend (Subplot). The red lines indicate the announcement date.

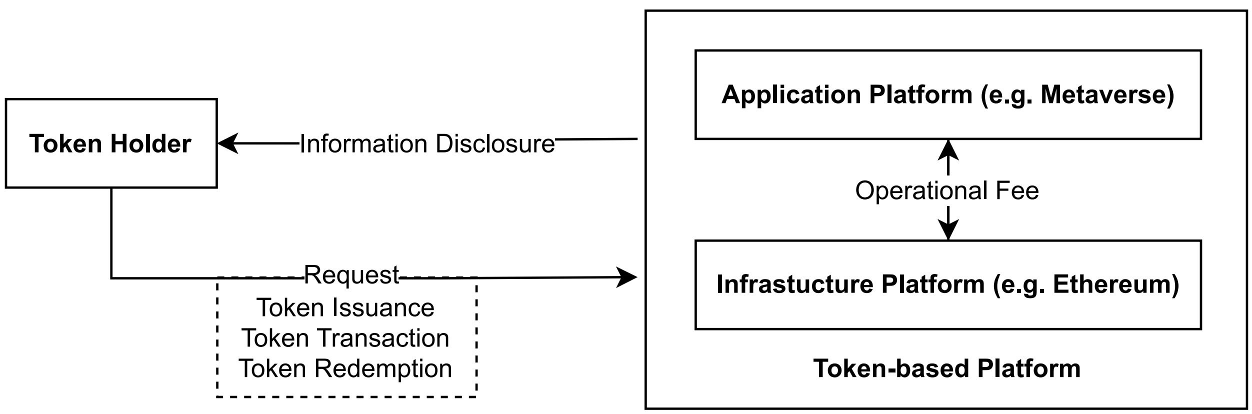

Figure 2: Layered Structure for Token-based Platforms

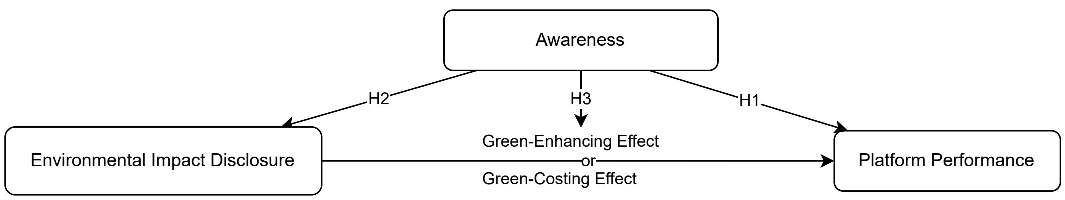

Figure 3: Research Model

Table 1: Statistics Summary

	Baseline (n = 23,570)				Post-Shock IP Disclosure (n = 40,768)			
Variable	Mean	Std	Min	Max	Mean	Std	Min	Max
TMVGR	-0.01	0.13	-3.38	3.39	-0.00	0.07	-1.44	1.50
PostShock	0.54	0.50	0.00	1.00	-	-	-	-
IP	0.33	0.47	0.00	1.00	-	-	-	-
Post	-	-	-	-	0.06	0.24	0.00	1.00
Environment	-	-	-	-	0.33	0.47	0.00	1.00
Size (million)	2,372.21	17,668.40	0.96	482,881.90	7,486.35	35,054.28	14.73	569,094.33
*AllMktcapChange**	-0.00	0.06	-0.26	0.16	-0.00	0.04	-0.26	0.16
WeekReturn	-0.06	0.26	-3.48	3.43	-0.02	0.24	-13.54	2.30
MonthReturn	-0.14	0.51	-4.18	3.81	-0.08	0.53	-13.70	2.46
ThreeMonthReturn	0.69	0.96	-2.37	8.33	-0.22	0.92	-14.42	3.83
Supply (million)	6,913.43	42,605.23	0.0	766,307.71	-	-	-	-
Close	812.14	6,048.65	0.00	82,745.19	-	-	-	-
Address	-	-	-	-	0.41	0.49	0.00	1.00
Registration	-	-	-	-	0.44	0.50	0.00	1.00

* "AllMktcap" indicates the overall token market value.

Table 2: Impact of Event Shock on IPs' and APs' TMVGRs

Dependent Variable	(1) TMVGR	(2) TMVGR	(3) TMVGR	(4) TMVGR	(5) TMVGR	(6) TMVGR
$PostShock_t \times IP_i$	-0.0053**	-0.0147***	-0.0144***	-0.0053**	-0.0147***	-0.0144***
	(0.0026)	(0.0029)	(0.0029)	(0.0022)	(0.0031)	(0.0049)
$\text{Log}(IP \times Supply)_{t-1}$	-	0.0205	0.0225	-	0.0205	0.0225
		(0.0222)	(0.0219)		(0.0229)	(0.0395)
$\text{Log}(IP \times Close)_{t-1}$	-	-0.0348***	0.0106	-	-0.0348***	0.0106
		(0.0085)	(0.0115)		(0.0087)	(0.0132)
$\text{Log}Size_{t-1}$	-	-0.0264***	-0.0415***	-	-0.0264***	-0.0415***
		(0.0054)	(0.0068)		(0.0044)	(0.0082)
Time Trend Control	No	Yes	Yes	No	Yes	Yes
Effects	Entity Time	Entity Time	Entity Time	Entity Time	Entity Time	Entity Time
No. Observations	23,570	23,570	23,570	23,570	23,570	23,570
Cov. Est.	Robust	Robust	Robust	Clustered	Clustered	Clustered
R-squared	0.0002	0.0052	0.0348	0.0002	0.0052	0.0348

Notes: The table reports the estimated coefficients (β) from Model 1 investigating the differential impact of the event shock on the TMVGRs of IP and AP. Entries in parentheses below the coefficient estimates are standard errors. Each column represents a different model variation with distinct control variables or estimation methods. 'Clustered' standard error groups at the platform level. "Time Trend Control" includes prior week return, prior month return, and prior three-month return. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Table 3: Number of Environmental Web Pages Published Before and After the Awareness Increase

IP	Published	Not Published	Total
Before Increase	7	78	85
After Increase	34	51	85
Total	41	130	170
AP	Published	Not Published	Total
Before Increase	0	105	105
After Increase	0	105	105
Total	0	210	210

Table 4: Effects of Web Page Environmental Impact Disclosures on IPs' TMVGRs

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	TMVGR	TMVGR	TMVGR	TMVGR	TMVGR	TMVGR
$Post_{it}$	0.0029**	0.0029**	0.0029**	0.0030***	0.0030***	0.0030***
	(0.0014)	(0.0014)	(0.0014)	(0.0011)	(0.0011)	(0.0011)
$PreShock_t \times Post_{it}$	-	-	-	-0.00103***	-0.0099***	-0.0098***
	-	-	-	(0.0023)	(0.0021)	(0.0021)
Log$Size_{t-1}$	-0.0076***	-0.0084***	-0.0083***	-0.0042***	-0.0042***	-0.0042***
	(0.0012)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
$AllMktcapChange_{t-1}$	-	-	-6.2604***	-	-	0.3002***
			(0.5852)			(0.0947)
Time Trend Control	No	Yes	Yes	No	Yes	Yes
Effects	Entity	Entity	Entity	Entity	Entity	Entity
	Time	Time	Time	Time	Time	Time
No. Observations	40,768	40,768	40,768	66,197	66,197	66,197
Cov. Est.	Clustered	Clustered	Clustered	Clustered	Clustered	Clustered
R-squared	0.0045	0.0050	0.0077	0.0025	0.0028	0.0031

Notes: This table reports the results of a staggered adoption DID study of model 3 and 4, examining the effects of environmental impact disclosure on IPs' TMVGRs. Entries in parentheses below the coefficient estimates are 'Clustered' standard error grouping at the platform level. "Time Trend Control" includes prior week return, prior month return, and prior three-month return. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Online Appendix A: Web Page Category Definitions

Category	Definition	Example
Introduction	Token-based platform introduction	Methods of mining
Tech Progress	Technique updates and bug report	Roadmap, Bug bounty program
Related Parties	Teams, forums, and partners	Partners, Forums
Join and Support	Join and support the platform	Jobs, donation
News and Blog	Company's news and blog	News, blog updates
Environmental	Contribution to the environment	Energy saving program, green mission
Social	Relationship with people and society	Social benefit program, general research
Governance	Governance policy	Voting rights allocation

Notes: For the classification of the 'Environmental' and 'Social' content, we followed the ESG (Environmental, Social, Governance) definitions provided by the U.S. Securities and Exchange Commission (US SEC).

Online Appendix: Figures

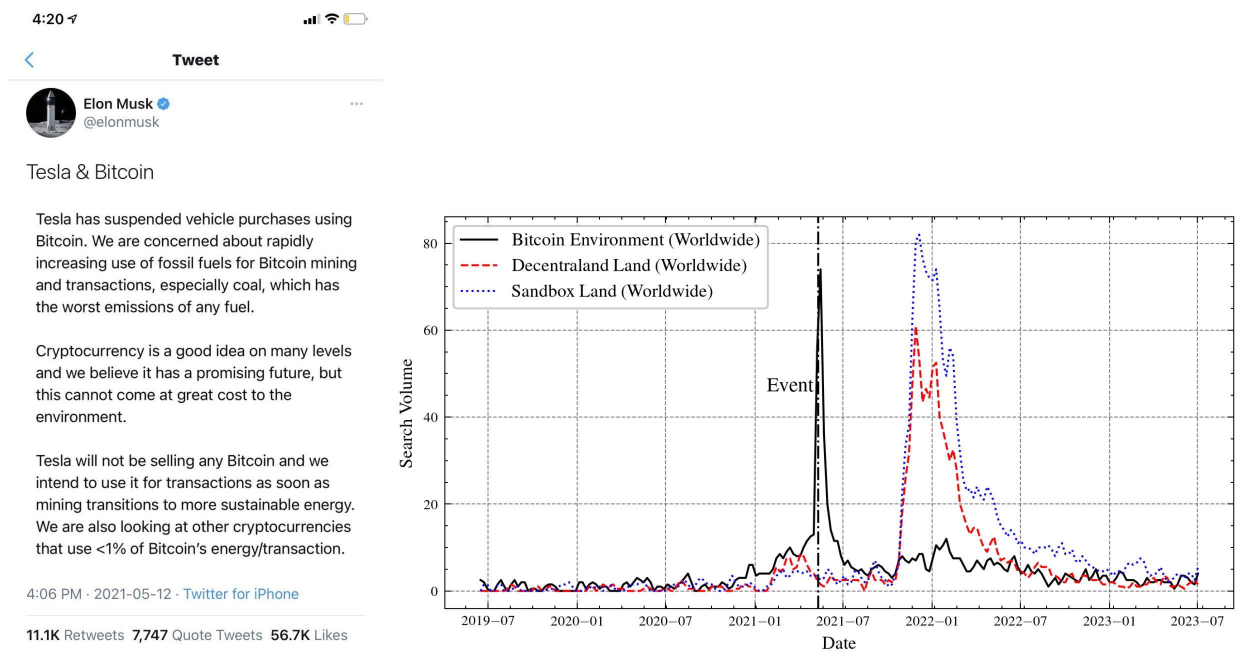

Figure 1: Elon Musk says Tesla will stop accepting Bitcoin for car purchases, citing environmental concerns. To show the significance level of the event, we include the Google Trend data of the hot topics in the Metaverse for comparison, including Decentraland land and Sandbox land.

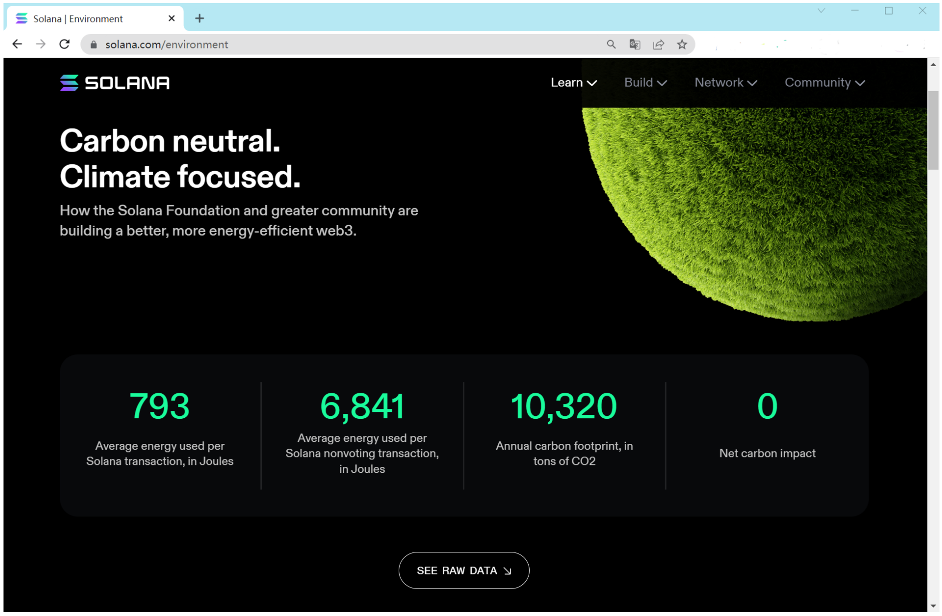

Figure 2: Environmental Web Page on Solana (Screenshot on July 1, 2023), Link: solana.com/environment

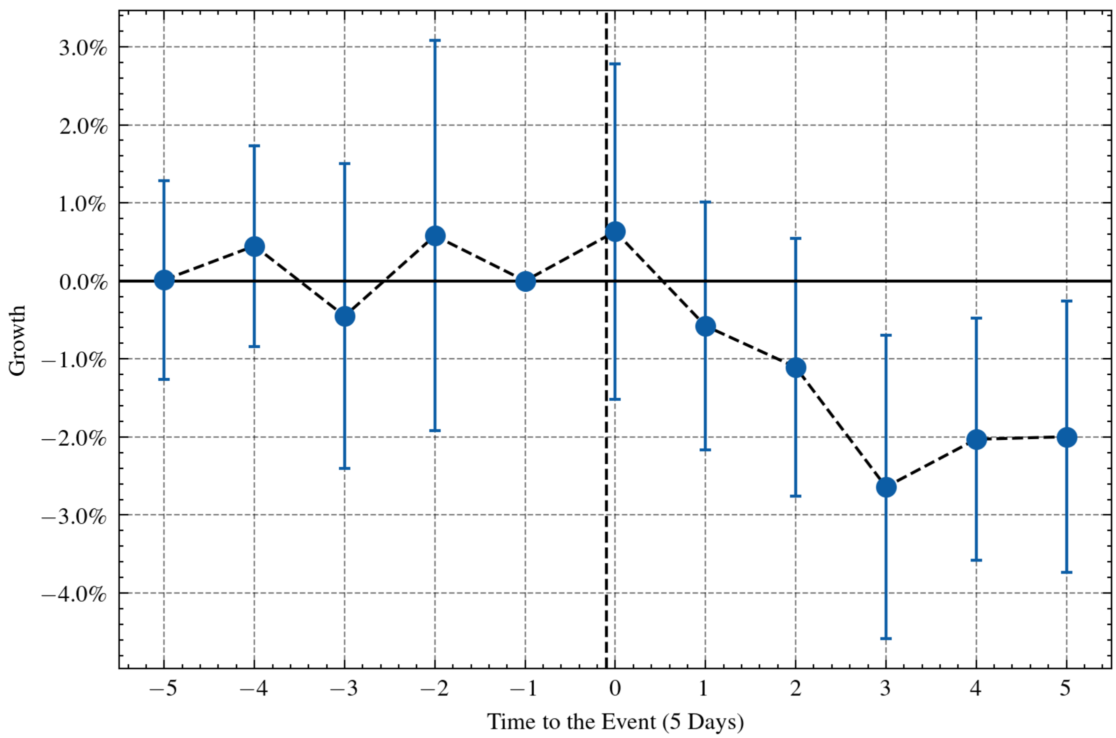

Figure 3: Estimated Effects of the Awareness on the TMVGRs of Token-Based Platforms

Online Appendix: Tables

Table 1: Environmental Web Page Launch Date of Top 200 Token-based Platforms (Calibrated)

Symbol	**Web Page**	Launch Date
EOS	https://eosauthority.com/green/	2018-11-25
XRP	https://xrpl.org/carbon-calculator.html	2020-10-21
NEAR	https://near.org/blog/near-climate-neutral-product/	2021-04-15
ALGO	https://algorand.com/about/sustainability	2021-04-22
CSPR	https://blog.casperlabs.io/new-power-usage-report-shows-the-casper-networks-impressive-energy-efficiency-relative-to-other-blockchain-protocols/	2021-05-04
HOT	https://www.holochain.org/projects/#energy_project	2021-05-05
MOB	https://mobilecoin.com/blog/mobilecoin-saves-on-environmental-footprint	2021-05-11
CRO	https://crypto.com/company-news/crypto-coms-climate-commitment-2	2021-05-27
GUSD	https://www.gemini.com/blog/introducing-gemini-green-offsetting-bitcoin-carbon-emissions	2021-06-23
MIOTA	https://blog.iota.org/climatecheck-and-the-iota-foundation-strengthen-their-collaboration-to-increase-trust-in-esg-data/	2021-06-29
ATOM	https://blog.cosmos.network/the-interchain-sustainability-mission-8d2e071d670d	2021-07-10
EGLD	https://multiversx.com/blog/elrond-carbon-negative-offsetra	2021-08-05
HBAR	https://github.com/hashgraph/guardian#readme	2021-10-10
KDA	https://kadenacommunity.medium.com/kadena-green-proof-of-work-e333f58a0c27	2021-10-12
HNT	https://www.helium.com/fr/environment-monitoring	2021-10-27
FTM	https://fantom.foundation/blog/fantom-the-eco-friendly-blockchain/	2021-11-23
BSV	https://www.bitcoinsv.com/sustainability	2021-11-28
FIL	https://green.filecoin.io/	2021-12-02
XTZ	https://tezos.com/carbon	2021-12-06
ETH	https://ethereum.org/en/energy-consumption/	2021-12-15
ADA	https://www.cardano.co.uk/our-approach-to-sustainability/	2022-01-23
FLOW	https://flow.com/sustainability	2022-02-13
QTUM	https://blog.qtum.org/how-green-is-qtum-d2d061146a65	2022-03-20
XDC	https://xdc.org/articles/the-xdc-network-a-sustainable-blockchain-solution-for-trade-finance-and-much	2022-03-22
IOTX	https://iotex.io/blog/100-million-blockchain-grant/	2022-03-23
CHSB	https://swissborg.com/blog/sustainability-roadmap	2022-03-23
MATIC	https://polygon.technology/sustainability	2022-04-11
THETA	https://docs.thetatoken.org/docs/what-is-theta-network#unique-consensus-mechanism-fast-and-green	2022-05-17
TFUEL	https://docs.thetatoken.org/docs/what-is-theta-network#unique-consensus-mechanism-fast-and-green	2022-05-17
XLM	https://www.stellar.org/foundation/sustainability	2022-05-22
FLUX	https://fluxofficial.medium.com/building-a-sustainable-blockchain-proof-of-useful-work-academic-on-flux-fd78ce3f20c8	2022-05-26
SOL	https://solana.com/zh/environment	2022-08-15
XCH	https://www.chia.net/2022/08/17/bringing-transparency-and-efficiency-to-carbon-markets/	2022-08-17
MATIC	https://polygon.technology/blog/the-merge-to-erase-60000-tonnes-of-polygons-carbon-footprint	2022-09-12
CELO	https://www.eventbrite.com/o/the-celo-foundation-41736322393	2022-10-30
AR	https://arweave.news/towards-a-green-model-of-proof-of-work-the-case-of-arweave-2-6/	2022-10-30
LTC	https://www.litecoin.net/news/litecoin-foundation-partner-with-metalpha-for-sustainable	2023-01-24
TRX	https://trondao.org/ecosystem-climate/	2023-01-25
LSK	https://lisk.com/blog/posts/blockchain-energy-markets	2023-02-05
FLR	https://flare.network/sparkles/	2023-03-02
DOT	https://polkadot.network/blog/a-year-in-parachains-part-4-sustainability-iot-nfts-gaming-metaverse	2023-03-08
VET	https://www.vechain.org/sustainability/	2023-03-12
ICP	https://internetcomputer.org/capabilities/sustainability	2023-03-15

Table 2: Conceptualization of Blockchain and Tokens

Leading IS Journal Papers	Blockchain Definition	Token Definition
Constantinides etl al. (ISR 2018)	Blockchain is a distributed ledger technology in the form of a distributed transactional database, secured by cryptography, and governed by a consensus mechanism	-
Ziolkowski et al. (JMIS 2020)	Blockchain technology has become a novel architecture to transact, maintain, and share data in a decentralized manner.	The representation of physical assets
Hendershott et al. (ISR 2021)	The essence of blockchain is a consensus system involving multiple parties and a strong security mechanism under an open architecture.	-
Sarker et al. (JMIS 2021)	Blockchain has been promoted as a revolutionary technology with the capacity to lower uncertainty, insecurity, and ambiguity in business transactions by providing single truth for all network participants.	-
Liang et al. (JMIS 2021)	Blockchain refers to a secure decentralized ledger of serial, peer-to-peer transactions without third-party intermediaries.	-
Cho et al. (JMIS 2021)	Blockchain technology strengthen data integrity by providing a decentralized system for facilitating, securing, and verifying transactions, which in turn sharpens the ability to detect and correct errors and to store transactions in a comprehensive, accurate, and up-to-date manner.	-
Bauer et al. (JMIS 2022)	Blockchain functions as an enabler for trusted, decentralized asset documentation.	The digital representations of real-world assets
Our work	Blockchain is a digital technology that securely and consistently records and verifies data across a decentralized network.	Digital representations of the ownership of both virtual and physical assets

Table 3: Impacts of Event Shock on IPs' and APs' TMVGRs over Time

Dependent Variable	(1) TMVGR	(2) TMVGR	(3) TMVGR
$IP_i \times \beta_{-5}$	0.0029	0.0007	0.0001
	(0.0064)	(0.0068)	(0.0065)
$IP_i \times \beta_{-4}$	0.0094	0.0026	0.0045
	(0.0064)	(0.0065)	(0.0066)
$IP_i \times \beta_{-3}$	0.0064	0.0032	-0.0045
	(0.0100)	(0.0095)	(0.0100)
$IP_i \times \beta_{-2}$	0.0154	0.0114	0.0058
	(0.0129)	(0.0125)	(0.0128)
$IP_i \times \beta_0$	0.0071	0.0015	0.0063
	(0.0117)	(0.0109)	(0.0110)
$IP_i \times \beta_1$	-0.0017	-0.0087	-0.0058
	(0.0075)	(0.0075)	(0.0081)
$IP_i \times \beta_2$	0.0019	-0.0104	-0.0111
	(0.0078)	(0.0081)	(0.0084)
$IP_i \times \beta_3$	0.0028	-0.0091	-0.0264***
	(0.0093)	(0.0096)	(0.0099)
$IP_i \times \beta_4$	0.0075	-0.0037	-0.0203**
	(0.0069)	(0.0071)	(0.0079)
$IP_i \times \beta_5$	0.0063	-0.0054	-0.0200**
	(0.0084)	(0.0085)	(0.0089)
Log$(IP_i \times Supply_{t-1})$		0.0028	0.0325
		(0.0271)	(0.0259)
Log$(IP_i \times Close_{t-1})$		-0.0151	0.0082
		(0.0101)	(0.0138)
Log$(IP_i \times Size_{t-1})$			-0.0504***
			(0.0095)
Time Trend Control	No	Yes	Yes
Effects	Entity	Entity	Entity
	Time	Time	Time
No. Observations	21,282	21,282	21,282
Cov. Est.	Clustered	Clustered	Clustered
R-squared	0.0005	0.0359	0.0394

Notes: The table demonstrates the result of the event study model. We exclude data that are not between β_{-6} and β_5 period to 21,282 data points. Entries in parentheses below the coefficient estimates are standard errors. The estimates account for the time before and after the event and include controls for various variables. Each column of the table includes a different set of control variables. The prefix 'IP:' denotes indicators of whether a platform belongs to IPs. β_k labels refer to k 5-days away from the shock, respectively. The estimates show changes in the TMVGR differences between IPs and APs over time. The asterisks denote the significance level of the coefficients, with *** p<0.01, ** p<0.05, and * p<0.1.

Table 4: Heterogeneous Effects of Web Page Environmental Disclosure

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	TMVGR	TMVGR	TMVGR	TMVGR	TMVGR	TMVGR
$Post_{it} \times Environment_i$	0.0039**	0.0039**				
	(0.0019)	(0.0019)				
$Post_{it} \times Registration_i$			-2.259e-05	-2.259e-05		
			(0.0024)	(0.0027)		
$Post_{it} \times Address_i$					0.0016	0.0016
					(0.0024)	(0.0025)
$Post_{it}$	-0.0021	-0.0021	0.0029*	0.0029*	0.0022	0.0022
	(0.0016)	(0.0016)	(0.0016)	(0.0017)	(0.0017)	(0.0014)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Effects	Entity	Entity	Entity	Entity	Entity	Entity
	Time	Time	Time	Time	Time	Time
No. Observations	59,780	59,780	40,768	40,768	40,768	40,768
Cov. Est.	Robust	Clustered	Robust	Clustered	Robust	Clustered
R-squared	0.0080	0.0080	0.0077	0.0077	0.0077	0.0077

Notes: Entries in parentheses below the coefficient estimates are standard errors. The 'Entity' and 'Time' effects incorporated in each model account for the platform-specific and the year-by-month-by-day fixed effects respectively. Two methods of covariance estimation are used: 'Robust', which is used when the standard errors are robust to heteroscedasticity, and 'Clustered', used when standard errors are calculated based on grouping at the platform level. Levels of significance for the coefficients are denoted by asterisks, with *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Table 5: Statistics Summary

	All-Period IP Disclosure (n = 66,197)				
Variable	Mean	Std	Min	Median	Max
TMVGR	0.00	0.07	-1.44	0.00	1.93
Size	5,957.75	29,324.90	1.97	861.09	569,094.33
AllMktcapChange	0.00	0.04	-0.26	0.00	0.16
WeekReturn	0.00	0.23	-13.54	-0.00	2.30
MonthReturn	-0.00	0.51	-13.70	-0.02	2.58
ThreeMonthReturn	-0.02	0.96	-14.42	-0.10	3.88
PostDisclosure	0.05	0.21	0.00	0.00	1.00
PreShock	0.36	0.48	0.00	0.00	1.00

Notes: "All-Period Disclosure Data" include data from both the pre-shock period and the post-shock period.